MUREP Small Business Technology Transfer (M-STTR) Planning Grants

Title: An Ultra-Efficient High-fidelity Tool for Thermomechanical Design of Tailorable Composites

Institution: University of Texas, Arlington

City/State: Arlington, Texas

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SUMMARY:
This proposal will enable a long-term collaboration between the University of Texas at Arlington (UTA), a *Hispanic-Serving Institution (HSI)*, and AnalySwift, LLC on the development of the transformational multiscale modeling approaches and software tools for advanced materials and structures, which will contribute to multiple NASA missions related to advanced aerospace materials and structures. Specifically, this proposal will address topic T12.07 Design Tools for Advanced Tailorable Composites in 2022 NASA STTR solicitation. The goal is to develop an integrated design framework for an efficient and accurate thermomechanical analysis of advanced tailorable composites. We propose to accomplish the following objectives:

Objective 1: Develop a graphical user interface (GUI) plug-in in commercial finite element (FE) tool. We will develop an intuitive and user-friendly GUI in Abaqus via Pythion scripts. The GUI will take all the design definition setups, call external codes for multiscale thermomechanical modeling, and perform structural analysis with the effective thermoelastic properties. The GUI will provide an integrated design framework for tow-steering composites. The thermomechanical modeling is based an advanced multiscale modeling approach called mechanics of structure genome (MSG), which will accurately and efficiently compute the location dependent, effective shell properties needed for structural analysis.

Objective 2: Demonstrate the use of the proposed tool for realistic space structures. We will perform thermomechanical analysis of a pressurized cylindrical structure with the developed framework and tools. The design variables are the spatially varying fiber paths in a tow-steering composite laminate. The mechanical and thermal loads will be applied to the structure. The thermomechanical responses of the structure with different design variables will be investigated using the proposed tool. The demonstration will be documented in the user manual and video.

Objective 3: Develop a machine learning (ML) module in the GUI to reduce the computational costs. We will add a ML module with two major functions in the Abaqus GUI. The first function will generate training datasets with the user-defined input (e.g., design variables) and output (e.g., responses of interest). The second function will train a ML model using artificial neural network (ANN). The parameters of an ANN model will be defined via the GUI, and the GUI will call Tensorflow, an open-source ML library, to train the ANN model. The trained ANN model will provide an ultra-efficient surrogate model for design optimization.